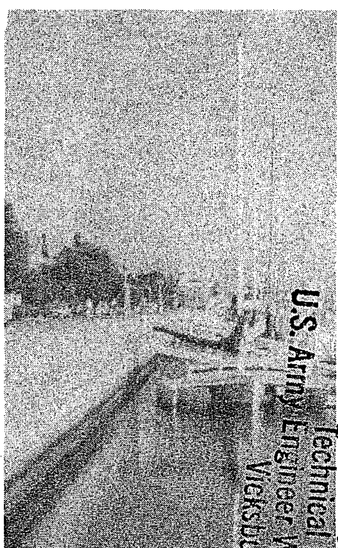
US Army Corps of Engineers

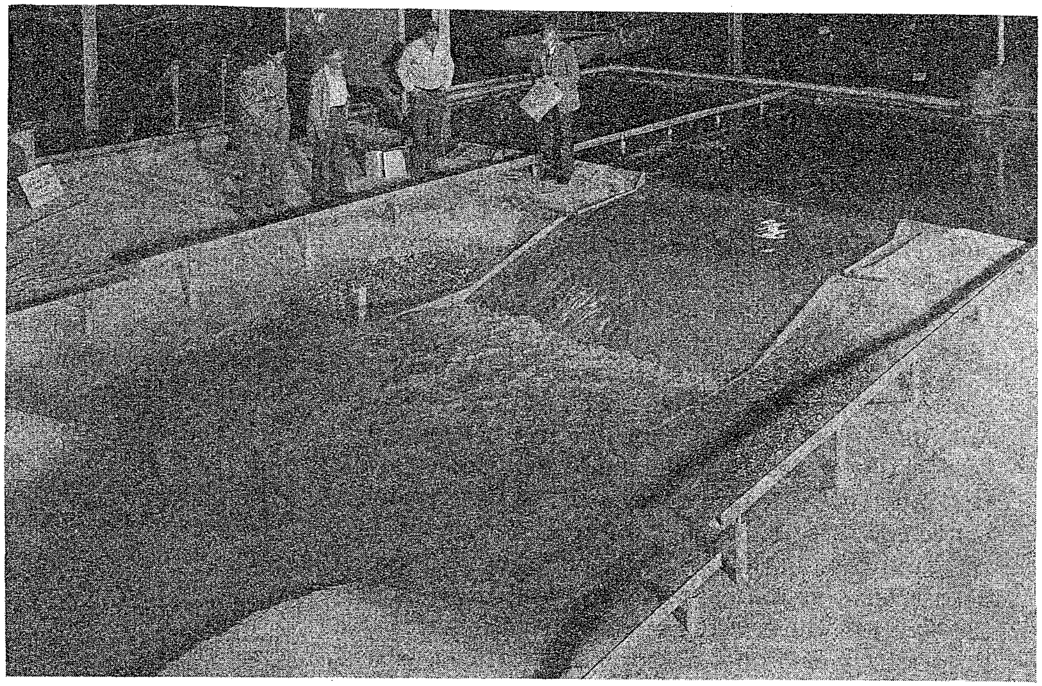


REMR RESEARCH PROGRAM

The REMR Bulletin

News from the Repair, Evaluation, Maintenance, and Rehabilitation Research Program

VOL 5, NO.1 INFORMATION EXCHANGE BULLETIN MAR 1988



Model study of Grapevine Spillway

Spillway Rehabilitation at Grapevine Lake Fort Worth District

by
Ronald L. Turner, US Army Engineer District, Fort Worth
Bob Fletcher, US Army Engineer Waterways Experiment Station

Grapevine Lake is located in Tarrant County, Texas, about 20 miles northwest of Dallas on Denton Creek. The dam is an earthfill embankment supporting an uncontrolled 500-foot-wide spillway with a low ogee crest (elevation 560*) and a 200-foot-long, V-shaped discharge chute. The discharge chute is at elevation 550 at the upstream end and 545 at the downstream end. Its longitudinal slope ranges from 2.5 percent along the training walls to 5 percent for the 100-foot-wide center strip. The outlet works consists of a 13-foot-diameter conduit controlled by two broom-type gates and two 30-inch, low-flow pipes paralleling the conduit. The project has a drainage area of 695 square miles. The spillway design flood volume is 797,800 acre-feet, with a peak routed outflow through the spillway of 182,500 cubic feet per second. The top of the dam serves as a roadway; originally, the road left the dam and crossed the

*All elevations cited herein are in feet referred to the National Geodetic Vertical Datum.

spillway channel about 700 feet downstream from the outfall of the spillway chute.

The spillway discharge channel was cut into a draw located north of the main channel. The cut channel is 750 feet long with an outfall elevation of 533 feet. Early design studies for the spillway indicated that erosion of the spillway channel downstream from the paved chute was expected, but the hard shales underneath the overburden material were thought to be resistant to erosion.

Overflow Problems

Since its completion in 1952, the spillway has overflowed twice. The first overflow occurred in 1957 when the lake pool reached elevation 560.8; the peak discharge was 520 cubic feet per second. The flow washed out the downstream road, but the damage was minor, and the road was repaired in the same location. The second time the spillway overtopped, the lake pool reached elevation 563.5, an elevation approximately equal to the 100-year pool of the lake. The peak discharge over the spillway was 9,100 cubic feet per second. (The spillway design flood would produce a flow of 191,000 cubic feet per second.) The flow, which lasted 21 days, caused severe erosion damage to the spillway discharge channel; a cut 40 feet deep eroded at the roadway crossing. Review of the damage convinced responsible officials that the spillway could not pass the design flood without extreme hazard to the structure.

To find a solution to the erosion problem, officials studied several alternatives. The studies indicated that the chute should be extended and that a stilling basin should be constructed downstream of the existing weir. Since another major overflow could possibly cause damage to or even loss of the existing spillway, funding for the program would have to be appropriated as soon as possible. The 1983 Jobs Bill provided 1.4 million dollars of the total 11.1 million dollars required.

Numerical Model

Of concern to the hydraulic designers was the transition from the V shape of the old chute to the planned horizontal shape of the chute extension. The question was whether there would be a concentration of flow along the center line of the extended chute and in the stilling basin as a result of the V bottom in the existing chute. Such a concentration could cause the stilling basin not to perform as designed. No two-dimensional-flow model which could be used to predict flow conditions on the chute could be found, and time constraints did not permit having the Waterways Experiment Station (WES) complete a physical model study. An analysis was, therefore, made by numerical methods. This analysis indicated that the amount of concentration of flow toward the center of the stilling basin was small and should cause no unpredictable flow conditions.

The chute extension and stilling basin were completed in May 1986. The stilling basin is 500 feet wide and 123 feet long and has two rows of baffle blocks. The apron elevation is 462. The top of the training walls is at elevation 495. The new chute is 308 feet long and has a slope of 3.5 horizontal to 1 vertical.

The roadway was relocated to cross the existing chute near the downstream toe. A slot was cut into the existing walls, and a new road was constructed to tie the new crossing into the old road on each side of the spillway. Since the elevation of the apron of the stilling basin is 78 feet lower than that of the road crossing, ground water is present in the stilling basin; therefore, guardrails and a chain link fence are provided for control of pedestrian traffic. The rails and fence are removed when spillway flow occurs (Figure 1).

Figure 1. The extended chute at the Grapevine Lake, Texas, spillway

Physical Model

The Grapevine project was selected for study under the REMR Research Program as a prototype for Corps projects that have the spillway located well above the floodplain elevation of the parent stream but do not have a stilling basin. A physical hydraulic model of the project was constructed and used for the study by the WES Hydraulics Laboratory (see cover photo).

The model was used to evaluate the causes of severe and excessive scour downstream of emergency spillways. It was used even further to develop better guidance for repair and rehabilitation of reaches between the emergency spillway and a downstream reach of quasi-stable exit channel or river. The causes of excessive erosion at these spillways were identified and are outlined in REMR Technical Note HY-FC-1.1. Guidance for evaluation of High Level Emergency Spillways (HLES) was established and is provided in REMR Technical Note HY-FC-1.2. REMR Technical Note HY-FC-1.3 describes possible structural modification for prevention of excessive scour downstream from HLES.

A video report entitled "Excessive Scour Downstream of High-Level Emergency Spillways" provides a 20-minute overview of this research.

The Geotechnical Laboratory at WES has also been studying the erosion problem in terms of the stratigraphic conditions of the unlined spillways. Technology has been developed that can be used to identify HLES which may experience excessive scour, and a search is on for remedial measures to control erosion. The point of contact for this work is James May, (601) 634-3395.

Ronald Turner is Chief of the General Hydraulics Section of the Forth Worth District. He has a B.S. degree in civil engineering from Texas A&M University and an M.S. degree in civil engineering (water resources) from the University of California, Berkeley. Turner is a Registered Professional Engineer in Texas and has been with the Fort Worth District for 22 years.

Bob Fletcher, a research hydraulic engineer in the Hydraulic Structures Division, Hydraulics Laboratory, WES, was principal investigator for REMR Work Unit 32277 "High-Level Emergency Spillway Scour." In recent years he has visited several prototype emergency spillways and conducted site specific and generalized model tests to investigate scour downstream from high-level emergency spillways. Fletcher received his B.S. degree in civil engineering from Mississippi State University. He has been with the Corps since 1962.

Ultrasonic Pulse-Echo Measurements of the Concrete Sea Wall at Marina Del Rey Los Angeles County, California

by
Henry T. Thornton and A. Michel Alexander
US Army Engineer Waterways Experiment Station

A new improved prototype ultrasonic pulse-echo system for concrete evaluation has been developed by Waterways Experiment Station (WES) researchers. This system uses piezoelectric crystals for both signal generation and detection. The 200-kilohertz two-transducer system has a signal-to-noise ratio (SNR) of 18. The weight and dimensions of the improved system have been reduced by 90 percent from the prior state-of-the-art system. The WES system, which has the shortest pulse length on record, works well in making thickness measurements of portland-cement concrete ($\leq$12 inches) and can indicate the presence of reinforcing steel, voids, and inferior quality concrete.

Background

Development of a practical system for use in the evaluation of concrete structures has been impeded by the heterogeneous nature of concrete and the state of the art of ultrasonic materials and techniques. Prior to the development of the WES system, the latest state-of-the-art system was developed at Ohio State University (OSU). The transducers used in the OSU system weighed 40 pounds and had a diameter of 18 inches (Figure 1). Measurements showed extraneous signals other than the desired longitudinal mode because of mode conversion in the transducers. Also, the transducers lacked proper focal length, directivity, and sensitivity.

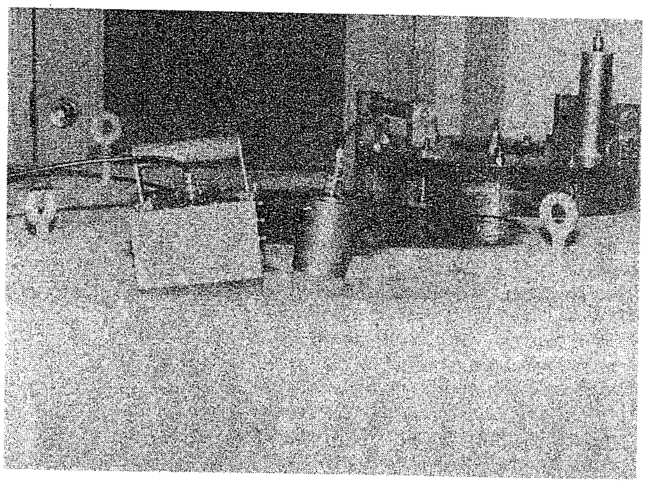


Figure 1. WES prototype system transducers in foreground, OSU transducers in right background.

The ultrasonic pulse-echo test consists of using the accurate time base of an oscilloscope to measure the time-of-flight of a longitudinal acoustic pulse in concrete. A short (2-3 cycles) 200-kilohertz pulse is introduced into the concrete at the accessible interface, such as concrete/air, is reflected from the backwall, and is received at the accessible surface by a second piezoelectric transducer. The ultrasonic pulse velocity of the concrete can be calculated from a measurement of the time it takes the pulse to travel the known distance to the backwall and return. After determining the velocity of sound concrete on a known thickness, other interface depths can be determined from a measurement of the time-of-flight of each echo. The measurement is then stored on a floppy disc for later analysis and plotting.

Marina Del Rey

In February 1986, a 60-foot section of the concrete retaining wall at Marina Del Rey failed because corrosion had completely destroyed the reinforcing steel. The 9-foot-high wall, which was constructed in 60-foot sections, is 10 inches thick at the bottom and tapers to 7 inches at the top. The wall is approximately 8 miles long (Figure 2).

Figure 2. Marina Del Rey, Los Angeles County, California.

In an examination following the failure, limited coring revealed some areas where the reinforcing steel is completely deteriorated and other areas where corrosion is just beginning. In some cases, but not all, the areas where corrosion is in progress can be identified by the rust-colored stain exuding from the horizontal construction joint between the footing and wall. The corrosion process is believed to be the result of the ingress of seawater through this horizontal construction joint and through a 6-inch layer of low-slump concrete placed on the footing just prior to placement of the wall.

In a search for nondestructive methods which would identify areas where severe deterioration of reinforcing steel had occurred, the staff of the Facilities Management Department, Los Angeles County, learned of the research program in progress at WES. The staff asked that the newly developed prototype ultrasonic pulse-echo system be applied to the problem at Marina Del Rey.

The purpose of the investigation was to delineate areas where reinforcing steel and concrete have deteriorated. It was believed that echoes could be received from the inaccessible backwall surface of the sea wall, from sound steel reinforcing bars located within the wall, and from voids created where the steel has corroded.

The velocity of sound concrete was determined from measurements made through 8 to 10 inches of the wall. Subsequent measurements were made in several locations within the marina in areas where the low-slump concrete was placed on the footing. The results of these measurements varied from receiving no signal at all (an indication of deteriorated concrete) to receiving reflections from various depths from the surface (an indication of the presence of reinforcing bar, flaws, and corrosion product).

Capabilities

Results of the preliminary tests with the prototype ultrasonic pulse-echo system at Marina Del Rey indicate that the system facilitates delineation of sound concrete, concrete of questionable quality, and deteriorated concrete. The presence or absence of the backwall echo, the noise preceding the backwall echo, and the SNR are all significant factors in making these delineations.

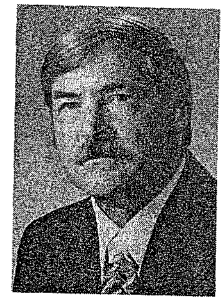
Preliminary test results indicate the system is also capable of detecting interfaces between sound concrete and reinforcing steel, interfaces between sound concrete and voids or cracks, and interfaces caused by corrosion product.

To obtain the best possible test results and the proper interpretation of those results, care should be taken to ensure that the operator of the system has had considerable experience using the system and interpreting the results. Also, proper intimate contact between the transducers and the concrete surface is a critical factor. In some areas surface preparation may be a definite requirement.

The prototype ultrasonic pulse-echo system performed better than expected in this particular application, and usable data were obtained. However, physical and electronic modifications can be made to significantly improve the effectiveness of the system. Better transducer contact and increased signal-to-noise ratios can be achieved.

For further information contact Henry T. Thornton, (601) 634-3797, or A. Michel Alexander, (601) 634-3237.

Henry Thornton is Chief, Evaluation and Monitoring Unit, Concrete Technology Division, Structures Laboratory, WES. He received his B.S. in mathematics and physics from Mississippi College and his M.S. in management science from the University of Miami. He is principal investigator for REMR Work Unit 32300, "Improved Nondestructive Testing Techniques for Concrete Structures."



A. Michel Alexander is a research physicist with the Structures Laboratory, WES. He has worked for 20 years in concrete research and in development of nondestructive testing techniques for evaluation of concrete structures. A member of the Mississippi Association of Physicists and the Society of American Military Engineers, he was graduated from Western Kentucky State University in 1964 with a B.S. in Physics and Mathematics. Alexander's position in Work Unit 32300 is primarily of a technical nature. He developed the apparatus and has submitted a disclosure to obtain a patent.

Environmental Impacts of Stilling Basin Dewaterings

by
Marc J. Zimmerman
US Army Engineer Waterways Experiment Station

Dewatering provides the best first-hand method of directly inspecting stilling basins and outlet channels. However, the procedure can cause adverse environmental effects on downstream aquatic natural resources and can also have significant economic impacts. This article addresses environmental concerns that arise when dewatering is used for periodic structural inspections of dams, stilling basins, and outlet channels. Site visits to projects in West Virginia, Ohio, New Mexico, Texas, and Kansas provide the basis for observations, recommendations, and speculations made here. Emphasis is placed on enhancing field operations which already run quite efficiently.

Although some general recommendations may apply to most projects, each project is unique. Difficulties may be encountered when methodologies are directly applied from projects of one size to projects of another, from projects located on small tributaries to projects on river mainstems, or from projects where gravity will drain most of the stilling basin and outlet channel to projects requiring cofferdam construction prior to pumping (Figures 1-3).

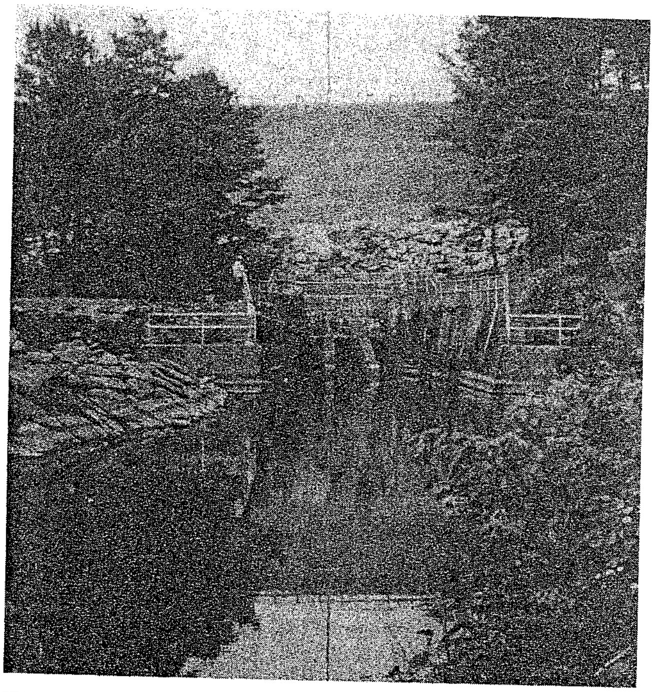


Figure 1. Differences in scale may affect requirements for dewaterings (Atwood Lake, Ohio)

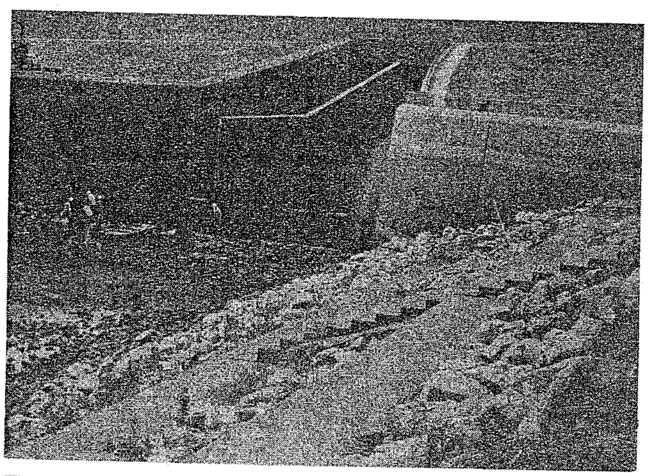


Figure 2. Differences in scale may affect requirements for dewaterings (Lake of the Pines, Texas)

Local conditions and project purposes—such as flood control, instream flow and water quality maintenance, and hydropower—affect specific techniques or approaches used for individual project dewaterings. For example, regular seasonal hydrologic fluctuations in the watershed of a flood-control tributary impoundment allow scheduling of dewaterings to minimally impact the

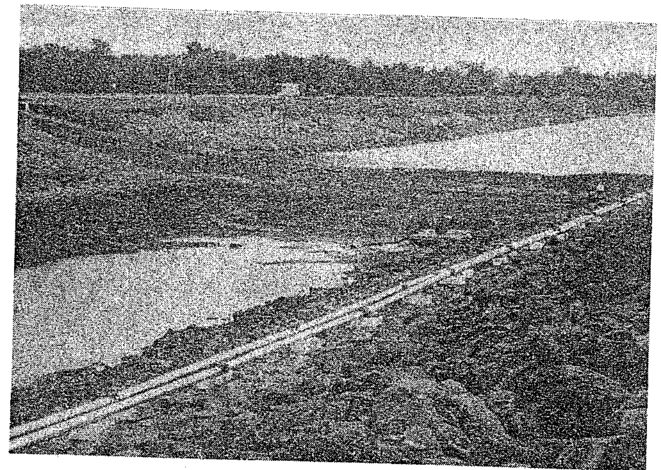


Figure 3. Cofferdam construction may be required in order to pump out stilling basins and outlet channels (Perry Lake, Kansas).

downstream environment. On the other hand, an inordinately expensive effort, likely to include pumping and siphoning, would be required to sustain instream flow and water quality needs during a normally brief inspection, and alternative inspection methods, such as using divers, would be more practical. Similarly, economic impacts from curtailing hydropower generation for an inspection dewatering could be severe.

The halting of water releases during a stilling basin dewatering may impair water quality. In summer, without aeration and replenishment, downstream waters may stagnate, thereby increasing water temperatures and decreasing concentrations of dissolved oxygen to levels inadequate for stream organisms. In winter, exposure to frigid temperatures may harm stream organisms. At any time of year, curtailing flows may cause organisms to concentrate in small pools because existing habitat and temporary refuge areas for aquatic species contract or disappear entirely. Mortality will likely increase because of overcrowding, predation, and poor water quality.

The greatest downstream environmental dangers in dewaterings occur when emergency inspections must be made to prevent possible major structural damage. Such an emergency inspection dewatering occurred at Abiquiu Dam in midwinter 1987 because of the fear of rockfall damage to the stilling basin floor (Figure 4). Repairs to the stilling basin floor at Abiquiu would have required extended winter work with all releases cut off and would have threatened to "freeze out" sections of the stream, killing all living organisms. Fortunately, the stilling basin floor suffered no damage, and flows were restored quickly.

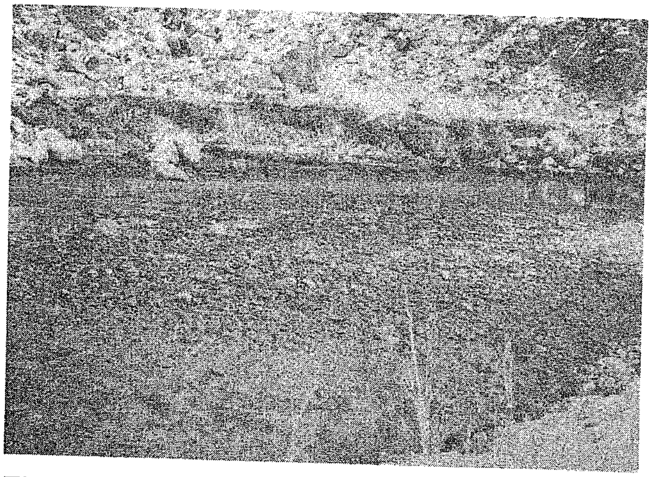


Figure 4. Extended, emergency curtailing of releases in winter may cause "freeze out" of stream beds. Fortunately, such a situation did not occur here (Abiquiu Lake, New Mexico).

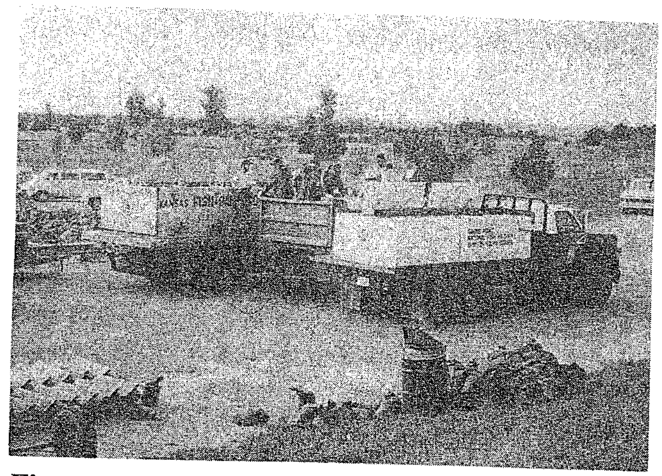


Figure 5. Coordination among several agencies can improve overall efficiency and create benefits through supplying hatchery breeding stock as shown here (Perry Lake, Kansas).

Ignoring biological considerations when planning a dewatering can exacerbate potential problems. If a critical time period in the life cycle of a valuable fish species is overlooked (for example, spawning or migration) and any of the previously noted conditions develop and persist, consequences could include significant population damage. Periods most suitable for dewaterings, that is, dry weather with relatively low flows, may coincide with propitious times for minimal impact on fish species. A forthcoming Waterways Experiment Station Technical Report "Seasonal Regulation of REMR Activities" elaborates on time-of-year considerations with respect to biological impacts. In addition, state wildlife agencies should be consulted for advice on minimizing impacts on local fish populations.

A major environmental impact is the potential loss of economically valuable fish species. Coordination with state wildlife agencies is standard practice in obtaining assistance in fish rescue operations associated with dewaterings. The US Fish and Wildlife Service may occasionally need breeding stock for fish hatcheries and may assist at a project dewatering where desired species may be taken in numbers sufficient to fill hatchery needs (Figure 5). "Rough" fish, such as carp, gar, and buffalo, do not pose great concern, although these species are sought by many recreational fishermen. Some delicate, rough fish, like shad, are neither edible nor rescuable but, in large numbers, can slow cleanup (Figure 6).

Applying a broad range of existing technologies can aid in minimizing fish losses that result from project dewaterings. Electroshocking, a relatively inexpensive, standard technique for estimating relative fish abundance can be used

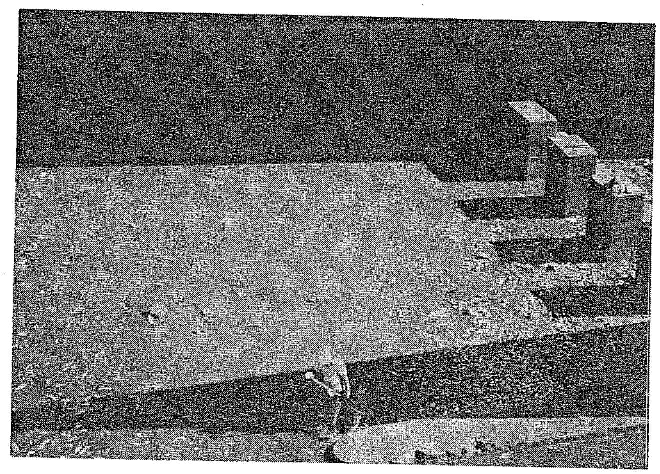


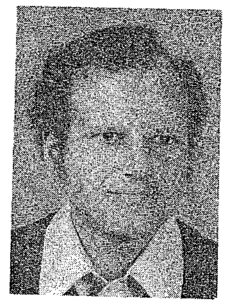
Figure 6. Fish mortality is an unavoidable effect of dewaterings. The fish pictured here are primarily shad (Wright Patman Lake, Texas).

in the outlet channel before dewatering. Most, if not all, state wildlife agencies use this nondestructive sampling technology. Underestimation of fish populations can create delays in completing inspections, increased costs, and an overworked labor force for the preinspection cleanup operation (a possible safety concern). By requesting an advance survey, project offices may avoid last minute problems. Nevertheless, environmental conditions and local fish distributions may change unexpectedly, and having extra personnel available will help ensure efficiency.

Other approaches that do not require complete dewatering are used in certain settings and should always be considered either as options for interim or reconnaissance measures before a dewatering and inspection. Some of these techniques are already subjects of REMR Technical Notes. Divers may perform inspections as noted in Technical Note CO-SE-1.1, "Diver Inspection of Coastal Structures." Many inland projects also use divers for inspections where dewatering is impracticable. In addition, underwater cameras may be useful to observe and inspect projects. Technical Note CS-ES-3.2, "Underwater Camera for Inspections of Structures in Turbid Water," describes the use of a still camera. The new video technology may prove underwater videophotography a viable inspection alternative since immediate viewing is possible. Videocameras should be used to document all aspects of dewaterings and inspections as the resultant record will provide a very clear depiction and running commentary for future inspections and planning.

Careful planning for dewatering should be the first concern of Corps personnel. The efficiency of a well-planned operation is reflected in the speed and safety with which work is completed. Minimizing environmental impacts should not be thought of as a hindrance to an inspection but rather as an integral part of the process. While structural integrity of a project is the reason for the inspection itself, the inspection period can be utilized to examine the aquatic tailwater resources of a project. In short, when an inspection is performed with efficiency and speed, time and money are saved, and environmental impacts are minimized.

For further information concerning environmental impacts of stilling basin dewaterings, contact Marc Zimmerman at (601) 634-3784.



Hydrologist Marc Zimmerman has worked in the Environmental Laboratory's Water Quality Modeling Group for 8 years. For the past 2 years, he has served on the editorial board of the journal, Regulated Rivers: Research and Management. Zimmerman holds a Ph.D. in zoology from the University of Georgia and a B.A. degree in biology from Case Western Reserve University.

SUPPLEMENT I OF THE REMR NOTEBOOK

Individuals who have a REMR Notebook should have received the first supplement. The supplement contains 30 technical notes and 11 material data sheets, which are color coded and in loose-leaf form for easy insertion into the The REMR Notebook. Those who have not received the supplement should notify the REMR Technology Transfer Specialist at (601) 634-2587.

The REMR Notebook contains information grouped according to the seven problem areas of the REMR program: Concrete and Steel Structures, Geotechnical, Hydraulics, Coastal, Electrical and Mechanical, Environmental Impacts, and Operations Management. Each Technical Note includes a statement of purpose, information about how, when, and where to apply the technology described, advantages and limitations of its use, cost and availability, and a point of contact for additional information or clarification.

For information concerning The REMR Notebook, contact the REMR Technology Transfer Specialist. Copies of the REMR Notebook are made available to nongovernment groups or individuals on a cost-reimbursable basis.

REMR NEWS IN BRIEF

John Cullinane has been named the new Problem Area Leader for the REMR Research Program's Environmental Impacts problem area. He replaced Dr. Jerome Mahloch, who served in this capacity since the program's inception.

Cullinane has worked for the Environmental Engineering Division for the last 10 years. He received a B.S. degree in Civil Engineering and an M.S. degree in Sanitary Engineering from Mississippi State University, and a law degree from Mississippi College, and is currently working toward a Ph.D. in Water Resource Engineering from the University of Texas.

■ ■ ■

Dr. Mahloch, an Environmental Engineer, has recently become a Program Manager with the Information Technology Laboratory. For the past 3 years he has managed the Water Operations Technical Support Program in the Environmental Laboratory along with his REMR problem area.

■ ■ ■

Mrs. Lee Byrne has been selected to succeed Mr. Bobby Baylot as the Technology Transfer Specialist for the REMR Research Program. Mrs. Byrne has been an editor in the Information Products Division, Information Technology Laboratory, since July 1986.

■ ■ ■

Appreciation is extended to Bobby Baylot for his special contributions to the REMR Research Program from July to December 1987. Bobby was promoted to Writer/Editor for the Environmental Analysis Center, Environmental Laboratory, in December 1987.

Request for Articles

If you have experience in any of the areas being addressed by the REMR Research Program, *The REMR Bulletin* is actively soliciting articles. Articles by individuals outside the Corps will be considered if relevant to REMR activities of the Corps.

To submit an article, write to: Commander and Director, US Army Engineer Waterways Experiment Station, ATTN: CEWES-SC-A, PO Box 631, Vicksburg, MS 39180-0631.

When submitting photographs with articles, please provide glossy prints or film rather than prescreened negatives.

WORKSHOP ON MANAGEMENT OF BIRD PESTS

The US Army Corps of Engineers will sponsor a workshop on bird problems at Civil Works projects. The workshop will be held April 27-29, 1988, at the Holiday Inn French Quarters in New Orleans.

Experts from the Bird Damage Control Section of the US Department of Agriculture and the US Army Construction Engineering Research Laboratory will offer information about the best current methods for managing bird pests consistent with environmental protection, how to develop a bird management program, and how to raise consciousness about the magnitude of the Civil Works bird problem to promote site-specific management strategies for bird control.

Personnel involved in management, operations, and maintenance of Civil Works projects are invited to participate in the workshop. There is no registration fee, but those interested in attending should reserve a slot before March 28, 1988, by calling (217) 352-6511.

Participants are responsible for making their own travel arrangements and hotel reservations. Rooms (at a special rate) have been blocked at the Holiday Inn French Quarter (504) 529-7211.

REMR Research Program

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	Office	Office Symbol	Commercial No.
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Overview Committee, HQUSACE			
James E. Crews (Chairman)	Operations Branch	CECW-OO	202-272-0242
Tony C. Liu	Structures Branch	CEEC-ED	202-272-8672
Program Management			
William F. McCleese (Program Manager)	Structures Laboratory, WES	CEWES-SC-A	601-634-2512
CPT Greg May (Deputy Program Manager)	Structures Laboratory, WES	CEWES-SC-A	601-634-3243
Lee Byrne (Technology Transfer Specialist)	Structures Laboratory, WES	CEWES-SC-A	601-634-2587
Problem Area Leaders			
James E. McDonald (Concrete and Steel Structures)	Structures Laboratory, WES	CEWES-SC-R	601-634-3230
G. Britt Mitchell (Geotechnical—Soils)	Geotechnical Laboratory, WES	CEWES-GE-E	601-634-2640
Jerry S. Huie (Geotechnical—Rock)	Geotechnical Laboratory, WES	CEWES-GR-M	601-634-2613
Glenn A. Pickering (Hydraulics)	Hydraulics Laboratory, WES	CEWES-HS-L	601-634-3344
D. D. Davidson (Coastal)	Coastal Engineering Research Center, WES	CEWES-CW-R	601-634-2722
Ashok Kumar (Electrical and Mechanical)	Construction Engineering Research Laboratory	CECEL-EM	217-373-7235
John Cullinane (Environmental Impacts)	Environmental Laboratory, WES	CEWES-EE-S	601-634-3723
Anthony M. Kao (Operations Management)	Construction Engineering Research Laboratory	CECEL-EM	217-373-7238
Field Review Group			
OPERATIONS MEMBERS:			
Thomas Pfeffer	Missouri River Division	CEMRD-CO-O	402-221-7289
James C. Wong	New England Division	CENED-OD-P	617-647-8411
Robert Neal	North Central Division	CENCD-CO	312-353-6378
John J. Sirak, Jr.	Ohio River Division	CEORD-CO-M	513-684-3418
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REMR Reports Published to Date

Number	*Date*	*Title*	*AD Number*
Unnumbered	Feb 1983	REMR Research Program Development Report, by J. M. Scanlon, Jr., J. E. McDonald, C. L. McAnear, E. D. Hart, R. W. Whalin, G. R. Williamson, and J. L. Mahloch	AD A125 998
Unnumbered	Sep 1985	The REMR Notebook	
Unnumbered	Jan 1987	Proceedings of REMR Workshop on Assessment of the Stability of Concrete Structures on Rock, 10-12 September 1985, compiled by W. F. McCleese	
TR REMR-CS-1	Sep 1984	Engineering Condition Survey of Concrete in Service, by R. L. Stowe and H. T. Thornton, Jr.	AD A148 893
TR REMR-CS-2	Apr 1985	The Condition of Corps of Engineers Civil Works Concrete Structures, by J. E. McDonald and R. L. Campbell, Jr.	AD A157 992
TR REMR-CS-3	Jul 1986	Latex Admixtures for Portland Cement Concrete and Mortar, by D. L. Bean and T. B. Husbands	AD A171 352
TR REMR-CS-4	Nov 1986	Repair of Waterstop Failures: Case Histories, by J. E. McDonald	AD A176 937
TR REMR-CS-5		Instrumentation Automation for Concrete Structures	
	Dec 1986	Report 1 Instrumentation Automation Techniques, by John Lindsey, David Edwards, Aubrey Keeter, Tom Payne, and Roger Malloy	AD A178 139
	Jun 1987	Report 2 Automation Hardware and Retrofitting Techniques, by Aubrey Keeter, Byron Stonecypher, Tom Payne, Mathew Skerl, Jim Burton, and James Jennings	
	Jun 1987	Report 3 Available Data Collection and Reduction Software, by Brian Currier and Marta H. Fenn	
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COVER PHOTOS

Cofferdam construction may be required in order to pump out stilling basins and outlet channels (Perry Lake, Kansas).

Marina Del Rey, Los Angeles County, California.

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DWAYNE G. LEE
Colonel, Corps of Engineers
Commander and Director

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